Tri-layer low-carbon distributed optimization of IES based on hybrid games under stochastic scenarios

Ziyi Yue[1], Huazhi Liu[2], Yonggang LI[3], Yuyao Zhong[1], Jiachen Yao[4], and Yuxuan Li[1]

[1]North China Electric Power University - Baoding Campus
[2]State Grid Tianjin Economic Research Institute
[3]North China Electric Power University
[4]Jibei Chengde Power Supply Company Chengde County Power Supply Branch Company

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Abstract

Low-carbon development of integrated energy systems is achieved via the sharing of multiple energy interactions by park-level integrated energy systems (PIESs). However, coordinating profit distribution conflict between complex interactive stakeholders under stochastic scenarios is challenging. Accordingly, this study proposes a novel tri-layer framework that aggregates different game mechanisms to investigate the interactions between PIESs and coupled energy markets. First, a linkage trading mechanism is proposed by integrating carbon emissions trading and green certificate trading , which establishes a coupled electricity-carbon-green certificate market. Consequently, a park aggregation operator acts as an intermediary between PIESs and the coupled market, setting purchase and sale prices to guide unit generation in each PIES using the master-slave game theory. Then, the Nash game theory is applied to realize a cooperative bargaining among PIESs for fair revenue distribution. Further, the impact of uncertain environments has been considered using stochastic scenario methods and the conditional value-at-risk theory. Furthermore, to protect the privacy of each participating agent while improving convergence speed, a differential evolutionary method is combined with analysis target cascading to solve the framework. Finally, the proposed scheduling method is verified using a typical case to optimize conflicting PIES interests in multiple scenarios and realize decarbonization transformation.

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